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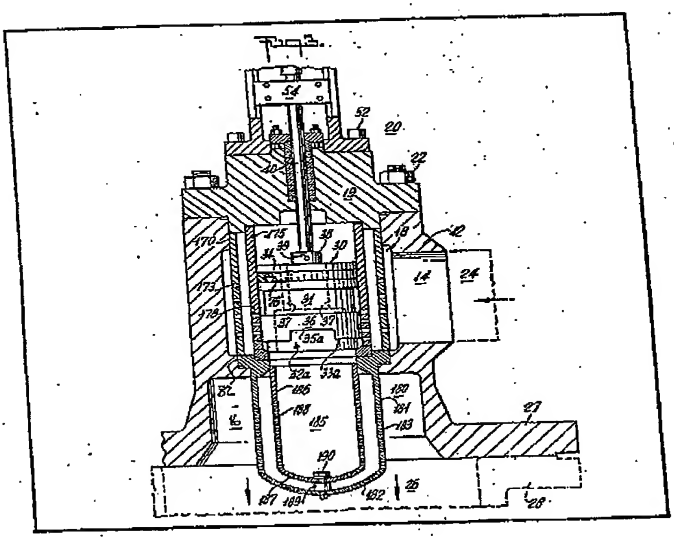
(54) Low Noise Valve

(57) A valve (20) for location in a fluid flow system communicating with a fluid conduit (26) to regulate flow while reducing the noise attendant therewith, comprises a valve body (12) having a pair of spaced-apart ports (14 and 16) and a central passage (18) therebetween, a diffuser means (180) disposed in one of the ports (16) extending into the fluid conduit (26), and a valve closure member (30) movably disposed in the central passage (18) for regulating fluid flow therethrough. The closure member (30) slides within a perforated sleeve (175) and, in the closed position of the valve, abuts a valve seat.



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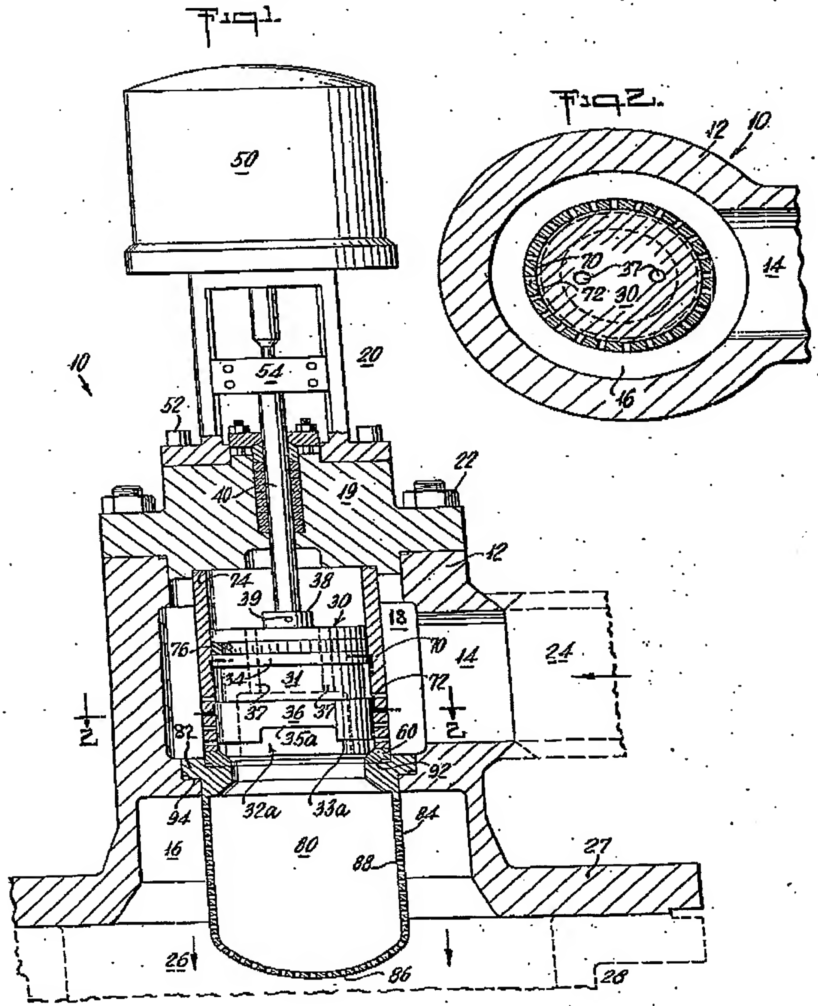
Fig 1.
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12
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34
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72
37
36
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82
35a
60
2
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32a
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84
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80
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Fig 2.
12
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Fig. 4

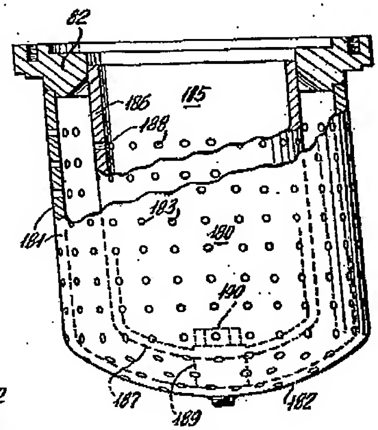

Fig. 3.

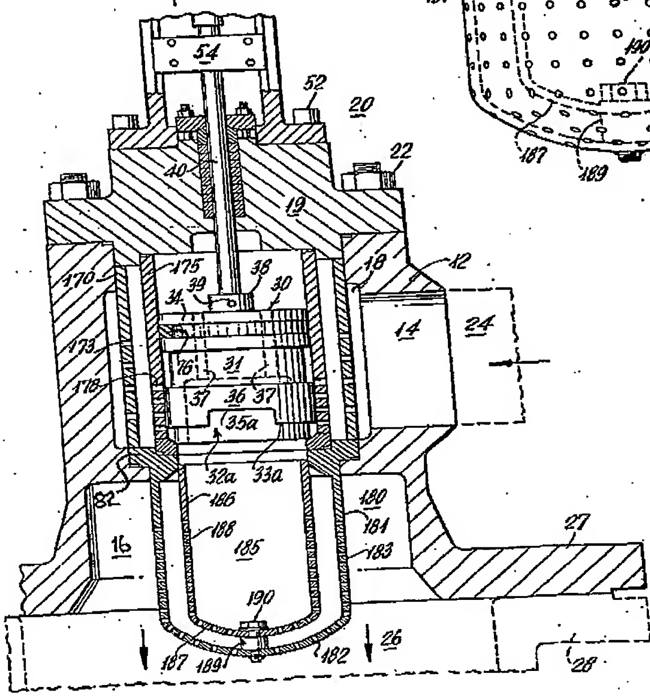

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Fig.8.

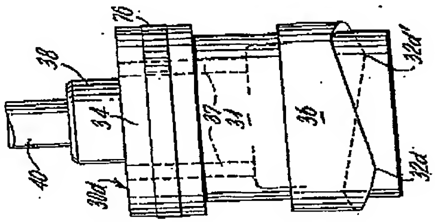


Fig.7.

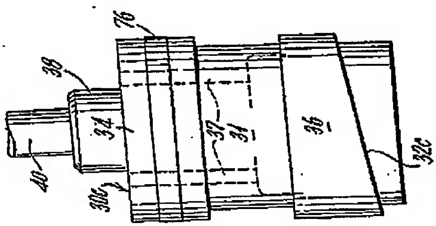


Fig.6.

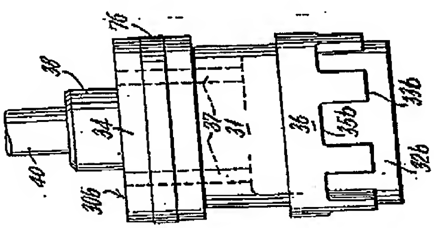


Fig.5.

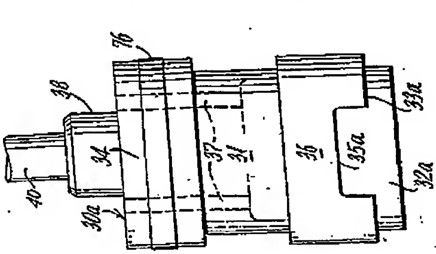


Fig.10.

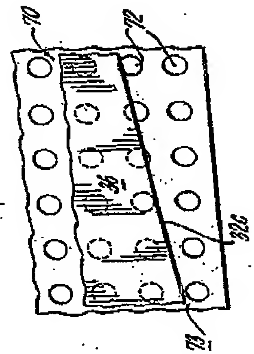
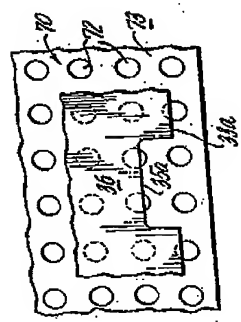


Fig.9.



SPECIFICATION
Low Noise Valve

The present invention relates to a low noise valve, for example a pressure-reducing valve especially useful in high pressure applications and in applications where smooth fluid flow characteristics are required. Unless special design features are incorporated to gradually reduce the pressure in a liquid or vapor system, several undesirable conditions may occur. As the pressure of a liquid suddenly is reduced, the liquid may cavitate, or vaporize. Later, the liquid may recondense inducing damaging shock waves, noise and excessive valve erosion. Similarly, as the pressure of a gas is reduced, the gas will expand thereby increasing the gas velocity. If the velocity of the expanding gas is not controlled to a level substantially less than sonic velocity, excessive erosion and noise may result. It is, therefore, desirable to dissipate energy from the fluid while gradually reducing the pressure.

In one arrangement to reduce fluid pressure, a plurality of valves is installed in series to reduce the pressure in stages. Installation of a plurality of valves in series is, however, unacceptably expensive for many applications. Several other arrangements for reducing fluid pressure and noise comprise dividing the fluid stream into a plurality of relatively small streams. These methods generally involve inserting pressure reducing plates in a fluid conduit, installation of a plurality of tortuous flow paths to dissipate fluid energy, or installation of a combination valve seat and diffuser concentric with the valve closure means. These methods, however, are not always successful. Replacement of perforated, pressure reducing plates in fluid conduits can be time consuming, requiring dismantling of conduit sections. In high pressure applications, the use of tortuous flow paths in the valve to accomplish the desired pressure reduction requires the use of relatively small perforations, often less than 1/8 inch in diameter if a single stage is used. Moreover, single stage reduction often results in excessive noise, erosion, valve damage, and pluggage of the cage perforations with foreign matter present in the fluid. Multi-stage pressure reduction in a valve incorporating tortuous flow paths results in an enlarged valve body increasingly susceptible to fouling. Use of a combination seat ring and diffuser may require the replacement of the diffuser every time the seat ring is replaced. Use of such a diffu ser also can decrease the capacity of the valve and requires that the inlet and outlet have the same dimensions and pressure rating.

Use of a conventional valve closure means in a low noise valve having a perforate cage may result in a step-wise, rather than a uniform, flow change as entire rows of perforations simultaneously are exposed or closed to the entering fluid. This is especially noticeable in a valve having substantial stem travel, where there may be a significant distance between adjacent rows of perforations.

An aim of the present invention is to provide a low noise pressure-reducing valve which is both quiet and reliable. With this aim in view, the present invention is directed to a valve for location in a fluid flow system communicating with a fluid conduit, for regulating flow rate and reducing noise attendant therewith, comprising a valve body having a pair of spaced-apart ports and a passage therebetween, a diffuser means positioned in one of the ports so that it would protrude into a fluid conduit which would be in communication with that one of ports when the valve is installed for use, the said diffuser means being adapted to divide fluid flowing through the port and fluid conduit, when the valve is in use, into a multiplicity of small streams and thereby reduce the noise associated therewith, and a valve closure means movably disposed in the passage for regulating fluid flow therethrough, whereby movement of the said valve closure means regulates the flow of fluid from one port to the other port through the passage and diffuser means.

Such a low noise valve can be constructed so that it is relatively inexpensive to manufacture, easily dismantled for repair and maintenance, and in which the inlet dimensions and inlet pressure rating may differ from those of the outlet.

Furthermore, the valve may have smooth flow characteristics throughout its range of operation.

Conventional, circumferential pressure reducing cage means may be incorporated in the valve body to provide further pressure reduction. Where circumferential cage means are used, the valve plug is preferably provided with one of the flow control surfaces described herein to relatively uniform increase the exposed perforated cage area as the plug is raised, thereby producing relatively smooth fluid flow characteristics.

Examples of a valve in accordance with the present invention are illustrated in the accompanying drawings, in which:—

Figures 1 and 3 are axial sectional elevational views of first and second such examples;

Figure 2 is a cross-sectional view of the valve shown in Figure 1, along line 2—2;

Figure 4 shows, on a larger scale, a partly sectional, partly cut away view of parts of the valve shown in Figure 3;

Figures 5 to 8 show elevational views of different forms for a part of the illustrated valves;

Figures 9 and 10 show respective views of portions of the part shown in Figures 5 and 7.

Referring first to Figures 1 and 2, a valve 10 has a body 12 with spaced-apart ports 14 and 16 and a central passage 18 therebetween. The centreline of port 14 is substantially perpendicular to the centreline of port 16. A conventional bonnet 19 is removably affixed to the valve body 12 by bolts and nuts 22. Valve closure means 20 comprises a plug means such as a plug 30 disposed in the central passage 18 for reciprocating movement, a stem 40 secured to the plug 30 by a bolt 39 passing through a hub

38 affixed to the plug 30, and operating means 50 removably attached to the bonnet 19 by bolts 52 and to the stem 40 by a coupling 54 for moving the plug 30 and the stem 40 in a reciprocating manner. The plug 30 has a central neck portion 31, an upper guide member 34 above the central portion 31, and a lower guide member 36 below the central section 31, the upper and lower guide members enabling smooth reciprocating movement of the plug 30 in the central passage 18, the lower guide member 36 having a flow control surface 32*a* on the bottom thereof described in more detail hereinafter. The plug 30 co-operates with a circumferential valve seat 60 located in the central passage 18 to provide a fluid-tight seal to fluid flowing through the central passage 18 between the ports 14 and 16. The plug 30 is shown with drilled holes 37 extending through the length of the plug 30 and with a sliding seal 76 disposed on the upper guide member 34. The holes 37 equalize the fluid pressure acting on the plug 30 from above and below, while the sliding seal 76 prevents fluid leakage around the plug and through the drilled holes. The plug 30, with its drilled holes 37 and sliding seal 76, is commonly referred to as a balanced or semi-balanced plug. This type of plug requires less plug actuating force than an unbalanced plug, although an unbalanced plug could be used. A fluid conduit 24, shown in broken lines, is illustrated welded to the valve body 12, while a flange 28 on a fluid conduit 26, also shown in broken lines, is removably attached to an outlet flange 27 of the valve body 12 by bolts (not shown). However, other conventional means may be utilized for connecting the fluid conduits 24 and 26 to the valve body 12. A cage means, such as a circumferential cage 70 having a multiplicity of perforations 72 therein, is disposed in the central passage 18 in concentric, surrounding relationship to the plug 30. Sealing means, such as a spirally wound gasket 74, may be disposed between the cage 70 and the bonnet 19 to prevent fluid leakage between the cage and the bonnet. A diffuser means, such as a diffuser 80, is disposed in the port 16 and protrudes into the fluid conduit 26. The diffuser 80 comprises a flange 82, a cylindrical section 84 extending from the flange 82, and a hemispherical cap 86 extending from the cylindrical section 84, the cylindrical section and cap being formed with a multiplicity of orifices 88 through them. A seal 92, located between the flange 82 and the seat 60, and a seal 94, located between that flange and the valve body 12, prevent fluid leakage around the flange. While diffuser 80 is shown having a cylindrical section 84 and a hemispherical cap 86, the overall shape of the diffuser is not critical to the utility of the valve. Similarly, the design of the operating means 50 is not critical.

Figures 3 and 4 disclose an example of a valve in accordance with the present invention which is similar to that shown in Figures 1 and 2, but which has a pair of cages and a pair of diffusers. Elements corresponding to those shown in Figures 1 and 2 have corresponding reference numerals. In this example, a cage 175 having perforations 178 through it is nested within a cage 170, which has perforations 173 through it, both cages being disposed in the central passage 18 surrounding the plug 30. A diffuser 180, comprising a cylindrical section 181 and a hemispherical cap 182 attached to the cylindrical section, both having orifices 183 through them, and a diffuser 185, comprising a cylindrical section 186 and a hemispherical cap 187 attached to the cylindrical section, both having orifices 188 through them, are retained in nested, spaced-apart relationship in port 16 by a bolt 190 and a spacer 189. Additional cage means or diffuser means could be added as dictated by the specific pressure-reduction requirements of each system. It should be noted that in both of the examples described herein, the cages, diffusers, plugs and seats are all removable from valve body 12 once the bonnet 19 has been removed, without disconnecting the valve body 12 from the fluid conduits 24 and 26.

Figures 5 to 8 illustrate four different forms of a plug which may be used in the illustrated valves to successively expose different perforations, for example perforations 72 within a row 73 of the cage 70 in the valve of Figure 1, to the entering fluid as the plug is moved away from the associated valve seat. All four of these plug forms operate in a substantially similar manner, the differences lying in the design of the flow control surface 32 located on the bottom of the lower guide member 36. Similar elements in the plugs have similar reference numerals, while the plugs themselves and their flow control surfaces 32 are distinguished one from another in Figures 5 to 8 by a suffix to the numeral. While the plugs shown in Figures 5 to 8 are formed with drilled holes 37 and sliding seals 76 to reduce the required plug actuating force, unbalanced plugs having flow control surfaces similar to those of Figures 5 to 8 could also be used in either one of the valves illustrated in Figures 1 to 4. In Figure 5, plug 30*a* is shown with a flow control surface 32*a* formed by a planar section 33*a* having a recess 35*a* therein designed to gradually expose perforations, for example perforations 72 within one or more of the rows 73 in the cage 70 of the valve of Figure 1, when the plug is elevated. This is shown in more detail in Figure 9. The plug shown in Figure 5 is the one illustrated in Figures 1 and 3. Plug 30*b*, illustrated in Figure 6, is generally similar to the plug 30*a* shown in Figure 5, having surfaces 32*b* comprising planar section 33*b* with a plurality of recesses 35*b* therein. Figure 7 illustrates a plug 30*c* having a slanting surface 32*c* which gradually exposes to fluid flow a series of perforations as the plug is raised, as shown in Figure 10. Plug 30*d*, shown in Figure 8, is similar to the embodiment of Figure 7, but has a pair of slanting surfaces slanting upwardly from locations 32*d* and 32*d'*, corresponding points on these surfaces being disposed 180 degrees apart.

Figure 9 illustrates the manner in which plug 30a of Figure 5 operates to gradually expose perforations in one or more rows 73 of a cage 70 to fluid flow, rather than exposing all perforations in a given row simultaneously. This results in substantially uniform changes in fluid flow rates through the valve as the plug 30a is moved up or down.

Figure 10 similarly illustrates the co-operation of the plug 30c with perforations 72 of a cage 70. Here, too, it can be seen that the perforations 72 within each row 73 are gradually exposed to entering fluid as plug 30c is elevated, resulting in substantially smooth valve operating characteristics. The plugs illustrated in Figures 6 and 8 operate in a substantially similar manner to those of Figures 5 and 7.

The valve plugs shown in Figures 5 to 8 could be used in prior-art low noise valves having one or more cages like cage 70 in Figure 1 surrounding the valve plug.

Referring again to Figures 1 and 2, when the valve plug 30 is elevated by operating means 50, fluid flows through the fluid conduit 24 in the direction shown by the arrow and enters the central passage 18 by way of the port 14. The fluid then passes through the perforations 72 in the cage 70 towards port 16, and thence through the orifices 88 in the diffuser 80 into the fluid conduit 26. The division of the fluid into a multiplicity of small streams by the perforations 72 in the cage 70 and the orifices 88 in the diffuser 80 is effective in dissipating the energy attendant with pressure reduction, resulting in a relatively quiet, pressure reducing valve. Conversely, as the plug 30 is moved closer to the seat 60 in the valve body 12, fewer perforations 72 are open for fluid flow thereby decreasing the flow rate. When any of the plugs illustrated in Figures 5 to 8 are used in a valve as illustrated in Figures 1 and 2, flow through each row 73 of perforations 72 is gradually reduced before each row is completely closed, resulting in substantially smooth valve flow characteristics. Conventional plugs, however, could be used in a valve otherwise as illustrated in Figures 1 and 2.

In laboratory tests a valve substantially similar to that shown in Figures 1 and 2 having an 8 inch (20.3 centimetre) 900 lb. (408.6 kilogram) rated inlet and a 30 inch (76.2 centimetre) 150 lb. (68.1 kilogram) outlet was used to reduce a steam flow rate of approximately 600,000 lb./hr. (262,400 kilogram/hour) from 1050 psia (73.82 kilogram/centimetre^2) to 14.7 psia (1.033 kilogram/centimetre^2). The pressure drop taken across the cage 70 was approximately 560 lb. (254.2 kilograms), while the pressure drop taken across the diffuser 80 was about 475 lb. (215.7 kilograms). The noise level reduction was calculated to be approximately 20 dBA from that which would have been experienced using a conventional single stage pressure reducing valve with conventional trim.

Referring again to Figures 3 and 4, when the plug 30 of the valve 10 is elevated away from its seat 60 by the stem 40 communicating with the operating means 50, fluid passes from the fluid conduit 24 by way of the port 14 into the central passage 18 when fluid flow is in the direction shown by the arrow. The fluid then passes through the perforations 173 in the cage 170 and the perforations 178 in the cage 175 towards the port 16. The fluid next flows through the orifices 183 of the diffuser 180 and the orifices 188 of the diffuser 185 out into the fluid conduit 26. High pressure and noise reduction is achieved by forcing the fluid to change direction repeatedly, thereby dissipating additional fluid energy. This can be achieved in this example by offsetting the perforations 173 in the cage 170 from the perforations 178 in the cage 175, and by offsetting the orifices 183 in the diffuser 180 from the orifices 188 in the diffuser 185. In most situations in which the valve could be used, the pressure should be reduced by about 50% or less across each diffuser or cage to keep the fluid velocity subsonic.

In both valve examples illustrated, the inlet port could be designed to be of a smaller diameter than the outlet port, while the outlet port could be designed for a lower pressure rating than the inlet if suitable provisions are made to prevent pressure build-up in the outlet port, such as by installing a pressure relief valve in the outlet fluid conduit.

Claims

1. A valve for location in a fluid flow system communicating with a fluid conduit, for regulating flow rate and reducing noise attendant therewith, comprising a valve body having a pair of spaced-apart ports and a passage therebetween, a diffuser means positioned in one of the ports so that it would protrude into a fluid conduit which would be in communication with that one of the ports when the valve is installed for use, the said diffuser means being adapted to divide fluid flowing through the port and fluid conduit, when the valve is in use, into a multiplicity of small streams and thereby reduce the noise associated therewith, and a valve closure means movably disposed in the passage for regulating fluid flow therethrough, whereby movement of the said valve closure means regulates the flow of fluid from one port to the other port through the passage and diffuser means.

2. A valve according to claim 1, further comprising a circumferential cage positioned in the passage and having a multiplicity of perforations through it, whereby fluid passing through the perforations on its way from one port to the other port, when the valve is in use, is divided into a multiplicity of small streams to thereby further reduce the noise attendant with the fluid flow.

3. A valve according to claim 2, wherein the said valve closure means includes a valve seat disposed in the passage and a plug means disposed for reciprocating movement in the passage and adapted to engage the said valve

seat, the said plug means having a flow control surface thereon for gradually exposing the perforations in the said circumferential cage to fluid flow, whereby movement of the said plug means away from said valve seat when the valve is in use gradually increases fluid flow from one port to the other port through the perforations in the said circumferential cage.

4. A valve according to claim 3, wherein the perforations in the said circumferential cage are arranged in rows, and wherein the said flow control surface co-operates with the said circumferential cage to successively expose different perforations within a row to fluid flow through the passage as the said plug means is moved away from the said valve seat.

5. A valve according to claim 4, wherein the said flow control surface comprises a planar section having a recess in it.

6. A valve according to claim 4, wherein the said flow control surface is slanted in relation to the said rows.

7. A valve according to any preceding claim, wherein the said diffuser means comprises a flange positioned in the said passage adjacent to the said one of the ports, a cylindrical section extending from the said flange, so as to protrude into a fluid conduit communicating with that one of the ports when the valve is in use, and a hemispherical cap extending from the said cylindrical section, the said cylindrical section and the said hemispherical cap being formed with a multiplicity of orifices through them, whereby fluid flowing through the passage from one port to the other port when the valve is in use is divided into a multiplicity of small streams by the orifices to thereby reduce the noise attendant with the fluid flow.

8. A valve according to claim 7, wherein the said diffuser means comprises a plurality of diffusers disposed in nested relationship, the orifices in each diffuser being offset relative to the orifices in the other diffuser, whereby fluid flowing through the passage from one port to the other port when the valve is in use must change direction to pass from one diffuser through the other diffuser.

9. A valve substantially as described herein with reference to Figures 1 and 2, or to Figures 3 and 4, or to Figures 1 and 2 modified in accordance with any one of Figures 6 to 8, or to Figures 3 and 4 modified in accordance with any one of Figures 6 to 8, of the accompanying drawings.

10. A low noise valve exhibiting substantially uniform fluid flow characteristics, for location in a fluid flow system communicating with a fluid conduit, comprising a valve body having a pair of spaced-apart ports and a passage therebetween, a valve seat disposed in the passage, a plug means disposed for reciprocating movement in the passage and for co-operative engagement with the said valve seat to regulate fluid flow through the passage, and a circumferential cage having a multiplicity of perforations through it arranged in rows to divide the fluid flow into a multiplicity of small streams and thereby reduce the noise attendant with fluid flow, and a flow control surface of the plug means co-operates with the circumferential cage whereby movement of the said plug means away from the said valve seat operates to successively expose different perforations within a row to fluid flow through the passage.

11. A valve according to claim 10, wherein the said flow control surface is slanted in relation to the said rows.

12. A valve according to claim 10, wherein the said flow control surface comprises a planar section having a recess in it.

13. A valve according to any one of claims 10 to 12, further comprising a diffuser means positioned in one of the ports so that it would protrude into a fluid conduit which would be in communication with that one of the ports when the valve is installed for use, said diffuser means being adapted to divide the fluid flowing through the port and fluid conduit, when the valve is in use, into a multiplicity of small streams thereby further reducing the noise associated with the fluid flow.

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